about one-half mile wide, but the reports indicate that it was due to a straight-line squall and not to a tornado.

At Steubenville, Jefferson County, three brick buildings were demolished, many buildings unroofed, and the steamer *Queen City*, with fifty passengers aboard, was blown from the wharf. Reports from Steubenville indicate that the damage there was done by a tornado; the loss was estimated to be $30,000.

There seem to have been well-defined funnel-shaped tornado clouds observed in a few instances, and the best defined are indicated by the heavy arrows in fig. 1. It is probable, however, that the wind in most instances was of the thundersquall type or straight-line squall. These winds are always more severe in some places than in others, but the current is broad and they lack the narrow, well-defined path of great destruction that marks the work of the tornado.

Tornadoes occur very rarely in Ohio. They may be known by the funnel-shaped cloud that hangs downward from the mass of clouds above. Wherever this funnel dips down to the earth it usually demolishes everything in its path.

SEVERE WINDSTORM IN SOUTH DAKOTA.

By S. W. GLENN, Section Director. Dated Huron, S. Dak., July 16, 1908.

A severe windstorm, attended by heavy rain and in some places by heavy hail, past southeastward over Brule County, S. Dak., on June 27, 1908. At the village of Pukwana, Brule County, where the storm appears to have attained its maximum intensity, five large business buildings, two churches, and three dwellings were demolished and practically every other building in the village was more or less damaged. A very remarkable feature of the storm was the absence of any fatalities and cases of serious injury. The storm struck Pukwana at about 10:50 p. m., and the destructive wind lasted about one minute and a half. On an extensive ranch adjacent to Pukwana all of the buildings were blown down and some live stock was killed. The storm extended west to Chamberlain and east to Kimball, in the same county, but was much less severe at these places. Because of the late hour when the storm occurred, it is impossible to say whether or not it had the marked peculiarities of a tornado, but a gentleman who visited the place soon afterward describes the arrangement of the débris in such way as to lead to the opinion that it was. The path of the destructive wind was about one-half mile wide. It past south of Kimball, damaging a few buildings and killing some live stock in that portion of the country.

TIDES OF THE SOLID EARTH, OBSERVED BY DOCTOR HECKER.[1]

By R. L. FARIS, Assistant, Coast and Geodetic Survey.
[Read before the Philosophical Society of Washington, May 23, 1908.]

The author's purpose in his paper is to present the most important results of a series of horizontal pendulum observations made for the purpose of studying the disturbances of the plumb-line under the attractive influence of the sun and moon.

The deflections of the plumb-line, as the author states, can be directly brought about in two ways thru the influence of the sun and moon; first by the sun's radiation causing a deformation of the surface of the ground, and thereby a consequent tilting disturbance of the pendulum, but producing no change in the direction of gravity; second, by their attractive effect, producing a deflection of the vertical or change in the direction of gravity.

The first systematic attempt to determine experimentally the lunar disturbance of gravity appears to have been made almost thirty years ago by Prof. G. H. Darwin,[2] at the suggestion of Sir William Thomson. While his experiments with a vertical pendulum apparatus at the surface of the ground lead to no conclusive results, yet he indicates in his report, submitted to the British Association in 1881, the possibility of securing the suitable conditions and instruments "amply sensitive enough for such a purpose."

In the second report upon the same subject, a year later, in 1882,[3] after discussing the amounts of distortion of the earth due to barometric and tidal oscillations, Darwin remarks that, we can not know these data for a 500-mile radius about a station so we can get an approximate idea of the slope of the surface. Even if these data were known the heterogeneity of the geological strata would be an obstacle to correct computation. It was his opinion at that time even "with gravitational instruments of very great delicacy, in the most favorable site, the record would show incessant variations of which no satisfactory account could be given." He, therefore, viewed the problem of experimentally determining the lunar disturbance of gravity as "exceedingly remote." But he adds in conclusion that, "by choosing a site where the flexure of the earth's surface is likely to be great, it is conceivable that a rough estimate might be made of the modulus of elasticity of the upper strata of the earth for 100 or 200 miles from the surface."

A quarter of a century later, in editing the first volume of his collected professional papers, Darwin has added a note to the above report, in which he indicates that in the light of Doctor Hecker's recent work with the horizontal pendulum at Potsdam, he has now reason to change his former view in reference to the instrumental measurements of the lunar disturbance of gravity.

Doctor Hecker bases his conclusions upon a continuous series of pendulum observations extending thru the twenty-eight months from December, 1902, to May, 1905. The pendulums were mounted in a room especially designed for the purpose, at a depth of 25 meters below the surface of the ground. This room, built of brick laid with cement, was connected with the well of the astrophysical observatory at Potsdam. The depth of 25 meters was chosen for the pendulum room in order to avoid the diurnal effect of the sun's radiation and to secure a sand foundation for the pendulum pier. The sand foundation, being less affected by moisture conditions, was also a favorable factor in eliminating the causes producing the apparent deflections of the plumb-line.

It appears from the author's statement that the temperature of the pendulum room remained practically constant at 11.7° centigrade.

The pendulum used was a modified form of von Rebeur's pendulum, consisting of two small brass tubes joined at right angles to form a T, the top being the vertical axis. The upper bearing of the vertical axis was a spherical sapphire of about 2 millimeters radius. The lower bearing was a sapphire plane. These sapphire bearings rested against steel points on the pendulum supports. The horizontal bar of the pendulum carried a 40-gram weight near its outer end. Two such pendulums, at right angles to each other, were mounted in independent supports fastened to a heavy triangular iron bedplate provided with three foot-screws which sat in the footplates upon the pier. The two separate pendulum supports, carrying the two pendulums, rested upon small steel points, two of which were small steel balls fitting into conical holes in the bedplate. The line joining these two points was parallel to the horizontal axis of the pendulum, while the third, also a steel ball, was fastened to the end of a slow-motion screw which past up thru the bedplate. By means of this screw the position of the zero point of the horizontal axis of the pendulum could be adjusted. Adequate means were pro-

[1] Beobachtungen an Horizontal-pendeln über die Deformation des Erdkörpers unter dem Einfluss von Sonne und Mond—von O. Hecker—Veröffentlichung d. k. Preus. Geod. Inst., N. F. No. 32—Berlin, 1907.

[2] Brit. Association Report, York meeting, 1881, pp. 93–126.

[3] British Association Report, 1882, p. 95–119.